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Final Report to the U.S. Fish and Wildlife Service
Big Muddy National Fish and Wildlife Refuge, Columbia, MO
December 2002, revised December 2003

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Chapter 4

Aquatic Invertebrates of Lisbon Bottom Wetlands

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Chapter 4. Aquatic Invertebrates of Lisbon Bottom Wetlands

Barry C. Poulton

Abstract

Aquatic macroinvertebrates were sampled both qualitatively and quantitatively from March–July 1999 to characterize the community composition and density in different types of wetlands at Lisbon Bottom based on water source, permanence, available vegetation structure, and timing of flood pulses. Twelve wetlands were sampled 1–2 times per month to document species richness (timed sweep-net sample), and eight wetlands were sampled at least once every two weeks for measuring macroinvertebrate density (0.24-m dia. stovepipe). From this study and previous macroinvertebrate research including adjacent riverine habitats (Lisbon Chute, mainstem Missouri River, etc.), a total of 260 species are known to exist in the Lisbon area, over half of which are unique to the flood-plain wetland complex. Richness of Odonata (dragonflies, damselflies), Coleoptera (beetles), Hemiptera (true bugs), and Ephemeroptera (mayflies) was high in vegetated areas of most wetlands; however, richness of Diptera (flies and mosquitoes) was lower than that reported in other studies and the Trichoptera (caddisflies) were nearly absent. Temporary wetlands held water throughout the winter months due to the fall 1998 flood, and the invertebrate community was dominated by overwintering species and groups of pioneer taxa that were available for dispersal to other basins after flooding occurred in mid-April. Species richness was lowest in deep scours, and highest in seasonal wetlands. Both species richness and density (#/m^2) were highest when margin vegetation was inundated, which corresponds with a period of 2–3 weeks after the flood pulse. Richness and density were also highest in seasonal wetlands; scours had lowest species richness throughout the early part of the study, but increased by late spring and summer periods. In all but the deep scours, the ratio of predator / herbivore-detritivores gradually declined during the study period, and the ratio of benthic / pelagic invertebrates peaked during the post-flood period. Both of these indicators appear to correspond with changes in the availability of organic matter due to flooding. Recommendations and goals for managing flood-plain wetlands for maximization of wildlife value will also maximize the availability and productivity of macroinvertebrate food sources for other wildlife species, while increasing biodiversity.

Introduction

The aquatic macroinvertebrate communities inhabiting many flood-plain habitats had not been previously studied within the Lower Missouri River flood plain. Most studies on mainstem invertebrates in the lower river had been conducted along the Nebraska-Iowa and South Dakota borders. Several pilot projects were initiated by the U.S. Army Corps of Engineers in the 1970s and 1980s, with the primary goal of evaluating the use of artificially created habitats in the mainstem of the river such as wing deflectors and slack water areas associated with dike fields. However, many habitats in the mainstem of the river had not been surveyed, and flood-plain wetland communities were largely ignored until the Missouri River Post-Flood Evaluation Project

(MRPE) study was initiated after the 1993 flood. Bataille and others (1999) listed a total of 85 taxa in the Lower Missouri River flood-plain wetlands that were examined in the MRPE study, but most of these were not identified past the family level. Further, wetlands were not sampled during the most diverse season (early spring), and both methods used in the wetlands were passive techniques (activity and emergence traps).

Between 1992–1998, aquatic macroinvertebrates in the Lower Missouri had become well known from the bioassessment and longitudinal evaluation studies conducted by the USGS Columbia Environmental Research Center (CERC) (Poulton and others, in press). As part of these studies, which concentrated on mainstem habitats, the Lisbon-Glasgow reach was included in the sampling regime, so the distribution of species among habitats and the species richness between habitats was reasonably well known before the Lisbon wetlands were examined in the present study. The newly created Lisbon Chute was also sampled in 1997 and 1998–99, using both petite ponar methods and a benthic trawl operated as fisheries gear. The goals of most of these studies were to characterize habitat and substrate types, and to develop a comprehensive taxa list for the lower river so that information on overall species richness of invertebrates in all habitats within the flood plain could eventually be obtained. Therefore, some data included in this study report are those from mainstem habitats being studied within the same general time period as the wetlands. When this Lisbon wetland study was initiated, the sampling regime was partially designed to address gaps in our knowledge on flood-plain invertebrates. These gaps included species richness within wetland complexes, examination of species composition as an aid in the further breakdown of wetland types, and the employment of more active sampling methods (sweep and stovepipe) during time periods that included the early and mid-spring season.

Methods

A total of 12 wetland basins were sampled for aquatic invertebrates from March 15–June 17, 1999 (fig. 4-1). Samples were taken only when water was present. Water temperature, water levels, and the presence or absence of inundated vegetation along the wetland margin were recorded during each sampling event. Two sampling methods were used: 1) quantitative samples were taken with a 0.24 m diameter stovepipe sampler to acquire estimates of invertebrate density (#/m^2), and 2) qualitative samples were taken with a 500 micron mesh D-frame sweep net to determine estimates of invertebrate species richness and relative abundance. All samples were preserved in the field with 80% ethanol in labeled, wide-mouth sample containers.

Quantitative Sampling

Of the eight wetlands sampled for invertebrate density, two of these were sampled once per week (Wetlands 8, 9) and the remaining six were sampled once every two weeks (Wetlands 2, 4, 10, 12, 22, 26). At each wetland, 10–12 suitable locations (depth less than 30 cm) along the wetland margin were marked with numbered stakes, and three of these locations were randomly chosen for sampling. The stovepipe was pushed by hand into the substrate to enclose the sampling area, and organisms were removed by sweeping a 500 micron aquarium net in a circular fashion throughout the enclosure for 3 minutes (fig. 4-2A). Organisms and debris were washed from the net into a white pan, concentrated with an ASTM #30 sieve, and placed into the sample container with preservative. Organisms were sorted from debris under a dissecting microscope with 10x magnification in the laboratory.

Qualitative Sampling

One qualitative sample was taken from each of the 12 wetland basins; four of the wetlands (5, 7, 11, 16) were sampled once per month, and the remaining 8 wetlands were sampled twice per month. For each sample, the D-frame net was swept repeatedly along the margin and emptied into a large white tray (fig. 4-2B). Organisms were hand-picked from the tray with a forceps, including those clinging to the net. An attempt was made to include as many different morphospecies as possible within a 30-minute period, or until approximately 100 organisms were picked. Invertebrates were enumerated and identified in the laboratory to the lowest possible level (usually genus or species) for each sample.

Analysis

To characterize the invertebrate species richness and density associated with the different types of flood-plain wetlands within Lisbon Bottom, and to examine the factors influencing flood-plain invertebrate biodiversity, wetlands were categorized by a combination of permanence, degree of influence from river or creek systems, basin morphology and formation, and vegetation type. Categories include: **1) deep scours** formed by levee breaks with little to no littoral zone or aquatic vegetation, **2) shallow scours** and/or remnants with a significant littoral zone, **3) semi-permanent** wetlands with significant aquatic vegetation that retain water for several months or the entire year, **4) seasonal** wetlands with prominent shoreline vegetation that hold water for at least 2–3 months and may have significant influence from flood-plain creeks, and **5) temporary** basins that are shallow depressions surrounded by moist-soil vegetation and retain water for no longer than 2–3 months after inundation. Because a few of the basins have characteristics that are associated with more than one category, some invertebrate relationships were developed with seasonal and semi-permanent basins combined into one group. This study represents an initial characterization of wetland invertebrate composition, and we have assumed that wetland classification schemes do not always account for a continuum of conditions. Therefore, the comparisons and general chronological trends reported in this chapter are based only on descriptive statistics, pending further analysis.

Samples were also qualitatively compared based on abundance and proportion of species richness for different functional feeding groups of invertebrates (Merritt and Cummins, 1996). These invertebrate categories were used to identify qualitative relationships between wetland type and function (table 4-1). Invertebrate species were subdivided into two basic functional feeding groups: **1) predators** (those feeding on other invertebrates), and **2) herbivore-detritivores** (those feeding on organic matter or living plant tissue). Species were also subdivided into: **A) benthic organisms** (those associated with bottom structure such as vegetation, organic matter, woody debris, or sediment), and **B) pelagic organisms** (those not associated with bottom structure or vegetation and are free-ranging swimmers). A third invertebrate category (“other”) included pleuston (species associated with the water surface) and semi-aquatic species (those associated with wetland margins above the water line). Estimates of invertebrate density (# / m^2) were also categorized based on percentiles (high > 5500; moderate = 1430–5500; low < 1430).

In 1999, the Missouri River mainstem and Lisbon Chute were not sampled for invertebrates during the same dates as the wetlands. However, species richness information from previous studies is included here for indicating relative importance of main channel and off-channel areas and their relative contribution to flood-plain biodiversity. The list of invertebrate species found in the mainstem of the Missouri River has been generated from other previous research (Poulton and others, in press), and also includes qualitative collections made from ongoing aquatic invertebrate studies from 1991-present. Part of this research used sampling designs that included stratification by different habitats (wing dikes, revetments, scour holes, sandbars, and the chute) and substrates (rock, sand, muck, organic snags, wood).

Results and Discussion

Wetland Status in 1999

At the beginning of the study in March 1999, several temporary wetlands contained small amounts of water remaining from the October 1998 flood event, which carried water into Lisbon Bottom from both north and south ends. Within the two months before the study, we observed dried filamentous algae on emergent plant stems as evidence that water levels in some scours along the cross-levee (19, 21) had dropped rapidly after river stages declined in December 1998. These wetlands may have a more direct ground-water connection with the river and had dried by the beginning of the study. However, Wetlands 2, 7, 8, and 9 contained water throughout the winter, and Wetland 22 remained hydrated because of the downstream transport of creek water from Wetland 11. All of these wetlands had dried by mid-April just before the first flood pulse.

On April 16, Lisbon Bottom began to flood and became completely covered with water. Water levels in the river receded periodically, and rose over flood stage again in early May (Chapter 2, fig. 2-4). By May 13, river levels had receded further and all of the wetlands were accessible and full of water, including Wetland 10 that requires higher river stages to fill and maintain water presence. Two additional flood pulses occurred that carried additional river water into the wetlands, one in late May and another in late June (fig. 2-4). Most of the temporary wetlands did not dry up until early August after sampling ended.

Invertebrate Response

A total of 260 macroinvertebrate species have been identified within mainstem and off-channel habitats in this river reach, over half of which are unique to the flood-plain wetlands (table 4-2). This total includes mainstem taxa that were reported at the family level in Bataille and others (1999), and were later keyed to genus and species so that they could be included at the same taxonomic level in this report. The mainstem of the Missouri River is dominated by the EPT taxa (Ephemeroptera, Plecoptera and Trichoptera), which make up nearly half of the species present (fig. 4-3). The wetlands at Lisbon Bottom are dominated by groups associated with lentic habitats, such as the Hemiptera, Coleoptera, and Odonata. Chironomid taxa richness between the two areas was similar, but made up a larger percent of the total taxa in the mainstem (fig. 4-3). The Missouri River mainstem and chute also contain some rare invertebrate species that are restricted to very large rivers, including some sand-dwelling mayflies and snag-dwelling stoneflies that have not been reported from any other locations within Missouri (table 4-2).

Temporary and seasonal wetlands were not expected to contribute to the local pool of overwintering invertebrate taxa because in the absence of an autumn flood, most of these basins would be dry. Fall flooding may also provide a higher degree of plant material conditioning, making organic substrates more attractive for invertebrates when they become inundated in spring (Reid, 1985). Because Wetlands 2, 7, 8, and 9 held water throughout the late fall and winter seasons, samples taken in the early part of the study period harbored pioneer species with high dispersal capabilities (adult beetles and Hemipterans), and a few species with relatively long life cycles (up to one year) that were carried in from the river or from adjacent, more permanent basins (that is, Ephemeroptera: *Hexagenia* spp.). Many of the Hemipterans and beetles that were collected in these wetlands at the beginning of the study normally overwinter in more permanent basins (Wiggins and others, 1980).

The most commonly collected pioneer taxa included the aquatic beetles *Berosus spp*. (Coleoptera: Hydrophilidae), *Peltodytes spp*. (Coleoptera: Haliplidae), and *Tropisternus spp*. (Coleoptera: Hydrophilidae), and the water boatmen *Trichocorixa spp.* (Hemiptera: Corixidae). These taxa were the dominant organisms both in the early part of the study and immediately after temporary basins were inundated after flood pulses. This finding differs from that in bottomland hardwood wetlands of the Mississippi alluvial plain, where amphipods, isopods, fingernail clams and chironomids have been reported as the dominant invertebrates (Batema and others, 1985).

Of the EPT taxa, one group that was expected to inhabit the wetlands more frequently were the Trichoptera, which normally are a diverse and dominant group in lentic habitats. In particular, the case-building families Limnephilidae, Phryganeidae, and Leptoceridae are common inhabitants of wetlands, ponds and weedy lakes in other parts of the U.S. (Wiggins, 1977). However, only one Trichoptera larvae was collected during the entire study. Because most species belonging to these families have life cycles of one year or longer, they probably require more permanent water bodies. Even though the deep scours we studied are permanent basins (4, 26), they may not be suitable for Trichoptera due to their lack of significant submerged or emergent aquatic vegetation. In contrast, there were a total of 12 species of Ephemeroptera collected from the Lisbon wetlands; several mayfly species are bivoltine and can survive periodically in seasonal or semi-permanent basins due to their shorter life cycles. The few individuals of Plecoptera collected during this study from Wetlands 11 and 22 probably drifted in from the creek system flowing through them, because some current exists there during higher flows. Our invertebrate density and species richness estimates in deep scours were low during the early part of the study. In these wetlands (4, 26), water boatmen (Hemiptera: Corixidae) and the glass shrimp (*Palaemonetes kadiakensis*) were the most dominant organisms along the margins and made up a significant portion of the taxa richness until water temperatures rose in early April. It is possible that some species may be using the deeper water as winter refuge and are inactive and not susceptible to capture during March sampling when colder water temperatures predominate.

Taxa Richness

In the wetlands, the number of both predator and herbivore-detritivore taxa peaked during the post-flood period in late May, and the relative proportion of herbivore-detritivore taxa decreased in nearly all wetland types as the study progressed (fig. 4-4). This result is similar to other research demonstrating that prolonged flooding causes greater changes in herbivores as opposed to predators (Murkin and Kadlec, 1986b), probably due to the succession of vegetation decay. However, the overall distribution of taxa present among all functional groups for the entire study period was similar for each of the wetland types; species richness of benthic herbivore-detritivores was highest (fig. 4-5). Through time, the lowest taxa richness occurred during the flood-pulse period, indicating possible dilution effects from the flooding. However, the highest taxa richness for most of the wetland types occurred after water levels had stabilized in mid- to late May, with the possible exception of seasonal wetlands which, collectively, had the highest taxa richness during the pre-flood period before mid-April (fig. 4-6). Taxa richness in Wetland 12 was consistently high throughout the study; we attribute this to higher diversity of interspersed cover types, which has been suggested as a plausible explanation for increased invertebrate diversity in wetlands (Andrews and Hasler, 1943, Voigts, 1976).

Total taxa richness in each wetland type ranged from 14–78 per time period (mean per sample = 4–42), which is higher than that reported in sweep samples taken at Little Bean Marsh (richness = 7–15), a permanent shallow wetland in the Missouri River flood plain (Heimann and Femmer, 1998). The literature suggests that temporary wetlands are typically low in diversity (Wiggins and others, 1980); our study does not support this. Even though taxa richness may be higher in temporaries during the spring following a fall flood as eluded to earlier, we also observed relatively high taxa richness in Wetland 10 within a few weeks after spring flooding, and this wetland was dry at the beginning of the study. It is also possible that vegetation decay and conditioning that occurs before flood pulses help provide attractive conditions for invertebrates when vegetation becomes flooded.

Benthic herbivore-detritivores also made up the largest percentage of the taxa richness throughout the study period. During the flood pulse, percent of taxa richness of this group actually increased in deep scours (fig. 4-7) and declined in temporary wetlands (fig. 4-8) as opposed to the pre-flood period. In contrast, taxa richness of benthic herbivore-detritivores declined in deep scours and increased in temporary wetlands by the post-flood period in late May. The taxa richness of benthic predators also increased in temporary wetlands during this period (fig. 4-8). Percent of taxa richness for all of the functional groups stabilized after the post-flood period into the summer months, except that pelagic herbivore-detritivores increased slightly in seasonal wetlands and shallow scours by July (figs. 4-9, 4-10).

Semi-aquatic and surface-dwelling invertebrates are expected to increase in importance as air temperatures rise in spring and the wetland margins become covered with new vegetation growth. All wetland types exhibited an increase in percent of taxa richness for these groups between pre-flood and post-flood periods. By June, these invertebrates made up approximately 9–17% of the taxa richness in the wetlands (fig. 4-11).

Abundance and Density

Because invertebrates are opportunistic and are adapted to a wide range of temporal habitat changes, the ratio of abundance of predators to herbivore-detritivores can be used as an indicator of community balance and changes in habitat conditions in wetlands. Herbivore-detritivore invertebrates take advantage of inundated wetland margins and benthic habitats, where organic matter provides a more readily available source of food and cover. This functional group is used as a food source by predators. In wetlands, when water levels drop sufficiently to the point where margin vegetation is no longer inundated, predators forage on remaining herbivorous invertebrates and become more dominant while herbivore-detritivores decline due to emergence and reduction in cover and organic matter availability. This pattern is evident at Lisbon, where gradual increases in the predator/herbivore-detritivore ratio occurred during the study. However, the ratio declined during flood pulses in deep scours (fig. 4-12).

Similarly, the ratio of benthic and pelagic invertebrate abundances can also indicate available habitat conditions for invertebrate functional groups, because true benthic invertebrates depend on bottom substrates and organic detritus that may become less available as summer progresses. Many of the pioneer invertebrate species with high dispersal capabilities are pelagic predators that can readily colonize new habitats as they become available, and are also the last taxa remaining in wetlands just before they dry up. Within each of the wetland types except the deep scours, the benthic/pelagic ratio peaked during the post-flood period, then declined through June and July (fig. 4-13).

Perennial vegetation, both new growth and that present from previous years, provides both organic matter for herbivorous invertebrates and structure for benthic predators. Availability and conditioning of this organic matter may play a critical role in determining the abundance of invertebrates during and after flood pulses. The moist-soil and woody vegetation along the margin of the Lisbon wetlands became inundated during flood pulses and remained partially flooded for several days after river levels receded. This post-flood period of mid- to late May provided a myriad of new habitats for dispersing and colonizing invertebrates, resulting in substantial increases in invertebrate density. Wetland 12 did not show this pattern, and had invertebrate densities an order of magnitude higher than most other wetlands (fig. 4-14). This wetland, which may be permanent in all but the driest of years, contained the highest diversity of submerged and emergent plants, the most stable water levels, and the least degree of influence from river flooding.

Our data suggest that inundated margin vegetation attracts higher densities and greater overall species richness of invertebrates as compared to periods when water levels in wetlands have declined or are in the process of drying up. For nearly every wetland type, a larger percentage of the number of quantitative samples taken are within the two highest density categories when margin vegetation is inundated (figs. 4-15, 4-16). About two-thirds of the samples taken from deep scours were within the lowest density class when margin vegetation was not inundated (fig. 4-16). In Wetland 12, over 80% of the invertebrate samples were taken when the vegetated margin was inundated, and it had the highest invertebrate densities observed during and throughout the entire study (figs. 4-14, 4-15). On May 3, no wetlands were accessible for sampling, but large densities of mosquito pupae (Diptera: Culicidae) were visible in flooded ditch areas near the roadway. In these areas, invertebrate densities were also among the highest observed during the study (see figs. 4-14, 4-15, 4-16). Temporary and seasonal pools and deep scours also showed an overall increase in invertebrate density after flood pulses receded, although some of this increase could be due to warmer air temperatures and a higher degree of insect activity in May and early June (fig. 4-14). Even though Wetland 11 was not sampled quantitatively, we observed high densities of snails (Gastropoda), particularly in the latter portion of the study from late May through July.

Relationship to Vertebrates

Aquatic invertebrates are an important food resource for fish and wildlife species. Fish may prey on invertebrates when they are present in wetlands, but it is unknown whether invertebrate-feeding fishes are dominant for long enough periods in the Missouri River flood plain to affect invertebrate populations. This group of fishes is sometimes poorly represented in wetlands; the Centrarchidae feed on invertebrates, but in deep scours at Lisbon the dominant species in this family are the crappies (*Pomoxis* spp.) that become piscivorous at a very early age (see Chapter 5). Temporary wetlands of Lisbon Bottom were dominated by various species that are known to be insectivorous (Pflieger, 1997), including shiners (*Notropis* spp. and *Cyprinella lutrensis*) and by orangespotted sunfish (*Lepomis humilis*) and green sunfish (*Lepomis cyanellus*) (see Chapter 5). Winged adult stages of insects are also utilized heavily by bats, many species of birds, and amphibians.

Perhaps the most well studied relationships between wetland invertebrates and higher animals that feed on them are those associated with waterfowl and shorebirds. Wetlands are important for providing invertebrate food resources because migrating waterfowl have higher protein requirements in spring just before nesting and egg-laying (Krull, 1970), and will shift food preferences from plant seeds to a higher protein diet consisting of invertebrates (Murkin and Wrubleski, 1988). Literature also suggests that wetland usage by species such as mallard (*Anas platyrhynchos*) and blue-winged teal (*Anas discors*) is strongly correlated with aquatic invertebrate density (Murkin and others, 1982), especially in the spring season (Murkin and Kadlec, 1986a). However, invertebrate groups that are listed by Eldridge (1990) as being the most often consumed by waterfowl, including Diptera, Gastropoda (snails), and zooplankton, were present at Lisbon, but were not the dominant groups collected in most of the wetlands in this study.

Several researchers have demonstrated that the combined attributes of invertebrate food resource availability, high plant stem density, and adequate interspersion of cover provides optimum conditions for waterfowl (Murkin and others, 1982; Lillie and Evrard, 1994). This presence of flooded vegetation interspersed with open water areas is also known as the hemi-marsh stage of wetland succession (Weller and Spatcher, 1965), a condition used to describe the optimum components needed for maximizing invertebrate productivity and corresponding avian use in shallow water bodies. Others have also demonstrated higher duck foraging frequency (Kaminski and Prince, 1981) in areas with highest invertebrate densities. There is also evidence that the interspersion of cover and structure in wetlands may provide cues to waterfowl that food densities are high (Mack and Flake, 1980; Nelson and Kadlec, 1984). Our research supports the conclusions found in these studies, because highest densities of invertebrates were observed in specific wetlands during time periods and conditions that corresponded with the highest observance of ducks (see Chapter 6). In our study, we observed conditions that are congruent with the hemi-marsh stage described above, both after river flooding (Wetlands 9 and10) and in seasonal wetlands that have high plant-water contact due to their connection with creek systems (Wetlands 11, 12, and 22).

Conclusions and Management Recommendations

The value of wetland invertebrates in organic matter processing, utilization and food-chain support for higher trophic levels has been well documented (Murkin and Wrubleski, 1988). Flood pulses within the Missouri River flood plain have historically occurred from early April through the middle of June in normal rainfall years. The timing of this flood-pulse is critical for supporting the needs of waterbirds because migration takes place regardless of local wetland status or condition. The invertebrate data from Lisbon suggests that the conditions for wetlands that are best for optimal usage by wildlife and fish in general, are periods within 1–2 weeks following the flood pulses when water levels have stabilized and open water areas are interspersed with inundated vegetation. These conditions can also be observed during spring seasons when surface water from creeks or localized rainfall is allowed to inundate moist-soil vegetation. This supports the results of many waterfowl studies that have demonstrated the importance of management techniques that maximize the production of invertebrate foods (Murkin and Kadlec, 1986a; Neckles and others, 1990).

Our data also suggest that temporary and seasonal wetlands may benefit significantly from a fall flood, which occurred in 1998 and also represented a historical condition. The wetlands that held water throughout the winter not only had some duck usage that may not have otherwise occurred during the early spring pre-flood period, but also harbor overwintering invertebrates that act as a local source of pioneer colonizers for recently flooded basins nearby. If the spring pulse does not occur until later in May after the peak of waterfowl migration, or if the river does not rise to a high enough level to fill up the basins, most temporary and some seasonal wetlands will not contain water or a food resource that is significant enough for optimum waterfowl usage. However, this may not be the case with wetlands that have a significant surface water input from creeks entering the flood plain. Wetlands 11 and 12 had the highest diversity of aquatic plants, among the highest species richness of invertebrates, and among the highest observed duck usage (see Chapter 6). These wetlands would likely be usable by waterfowl even if the migration peak takes place before river levels rise enough to fill other, more temporary basins. Scour wetlands (4, 26) were still used as resting areas by ducks even though these basins do not have a significant littoral zone available for invertebrate feeding (see Chapter 6).

The invertebrate data from this study suggests that both organic matter utilization by aquatic invertebrates and high invertebrate food densities can be maximized by managing wetland areas so that margin vegetation can be inundated periodically, especially when warmer water temperatures begin to dominate in spring and the flight dispersal and egg-laying habits of insects is high. This period also coincides with the migration peak for many bird species, and is also congruent with the peak in shorebird activity that occurs shortly after that of waterfowl. Invertebrate species in flood-plain wetlands are adapted to these changes, with either relatively short life cycles or dessicant-resistant stages that allow them to survive in temporary basins, or high dispersal capabilities that enable them to quickly move from more permanent wetlands to newly flooded areas (Reid, 1985). Previous research also suggests that many invertebrates adapted to temporary habitats are among the most important foods for wildlife, yet these species cannot exist in more permanent wetlands (Eldridge, 1990). Two examples of taxa that require habitats subjected to intermittent flooding and drying cycles include mosquito larvae (Diptera: Culicidae) and the clam shrimp (Crustacea: Conchostraca).

There has been very little active management at Lisbon Bottom; the wetland complex has been largely formed by natural processes. Several papers have recommended the management and preservation of entire wetland complexes because they provide a large variety of vegetation and hydration regimes, and will naturally have higher invertebrate diversity and migrating waterfowl usage because the increased range of conditions allow utilization under a wider variety of environmental conditions (Talent and others, 1982; Fredrickson and Reid, 1988). The wider range of conditions in water permanence that wetland complexes may provide also can increase overall invertebrate diversity within the area due to increased niche partitioning and the wide range of life cycle strategies that are used among wetland macroinvertebrates species. The goal for many flood-plain areas along large rivers could be to strive for a maximum diversity of wetland types based on permanence, surrounding vegetation, water source, and basin morphology. Lisbon is already such an area, even though little effort has been spent on management. Some wetlands are always available for fish and wildlife usage, regardless of season, because Lisbon contains wetland basins across a continuum from shallow temporary to deeper more permanent.

Based on the information we now have from the wetland complex at Lisbon Bottom, two primary management techniques or goals can be recommended for optimizing habitat conditions and the diversity and availability of aquatic invertebrates: 1) allow flood-plain creeks that have been historically diverted to re-enter the flood plain and provide an additional source of surface water, while also increasing beneficial moist-soil vegetation, and 2) provide additional routes (or maintain present ones) for river water to periodically enter the flood plain at stages that are lower than the flood level. This would include leaving existing levee breaks in place or adding small notches or crevasses in primary levees where appropriate. One positive result of this would be to increase the relative area and diversity of moist-soil vegetation, a management goal that is often recommended for waterfowl and other wildlife (McCrady and others, 1986). Management of some areas containing flood-plain wetlands has also included techniques that would stabilize water levels at elevations that provide inundated vegetation at the right time periods and/or increase the permanence of some wetland basins that might otherwise not hold water for long enough periods to provide maximum benefit for wildlife. At least two examples of this type of management are already occurring in other areas of the Missouri River flood plain. This type of active management may be appropriate for specific basin types or uses within an area (that is, those previously altered), as long as the dynamic processes of natural flooding and drying are maintained in other wetland basins within the same complex. If wetland succession causes the eventual elimination of some shallow temporaries, or decreases the depth and size of other wetland types (such as scours), providing water level manipulation as a form of active management in some basins would assure continued availability for both macroinvertebrates and other wildlife.

Our results suggest that habitat management and rehabilitation efforts that focus on enhancement of the natural formation of diverse wetland complexes with a wide range of permanence and vegetation types will be of great benefit to macroinvertebrate biodiversity and wildlife value within the Missouri River flood plain. Further, the life history traits of macroinvertebrates present in an individual wetland can give a past history of the water regime, and aid in the classification and management of different wetland types so that their own distinct communities can be maintained.

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Table 4-1. List of basic functional groups of aquatic macroinvertebrates collected at Lisbon Bottom, Spring 1999 (from Merritt & Cummins, 1996). Pr = Predators, Hd = Herbivore/Detritivores, Pe = Pelagic, Be = Benthic, Pl = Pleuston, Sa = Semi-aquatic

Taxonomic group	Families / Genera from Lisbon included	Pr	Hd	Pe	Be	Pl	Sa
Turbellaria (flatworms)	Planariidae	---	X	---	X	---	---
Oligochaeta (segmented worms)	Tubificidae, Naididae	---	X	---	X	---	---
Hirudinea (leeches)	Glossiphoniidae	---	X	---	X	---	---
Nematomorpha (horsehair worms)	Gordiidae	---	X	---	X	---	---
Pelecypoda (clams)	Sphaeriidae	---	X	---	X	---	---
Gastropoda (snails)	Physidae, Lymnaidae, Hydrobiidae	---	X	---	X	---	---
Decapoda (shrimps and crayfishes)	Palaemoniidae, Orconectidae	---	X	---	X	---	---
Amphipoda (scuds)	Gammaridae, Taltridae	---	X	---	X	---	---
Eubranchiopoda (clam shrimp)	Conchostraca	---	X	X	---	---	---
Collembolla (springtails)	Entomobryidae	---	X	---	---	X	---
Hemiptera (true bugs)	Gerridae, Veliidae	---	X	---	---	---	---
Hemiptera (true bugs)	Gelastocoridae, Hydrometridae, Mesoveliidae, Saldidae	X	---	---	---	---	X
Hemiptera (true bugs)	Notonectidae, Belostomatidae, Naucoridae, Corixidae (except Hesperocorixa and Sigara), Pleidae	X	---	X	---	---	---
Hemiptera (true bugs)	Corixidae (Hesperocorixa and Sigara only)	---	X	X	---	---	---
Hemiptera (true bugs)	Nepidae	X	---	---	X	---	---
Ephemeroptera (mayflies)	Tricorythidae, Leptophlebiidae, Baetidae, Ephemeridae, Caenidae, Heptageniidae	---	X	---	X	---	---
Plecoptera (stoneflies)	Perlidae	X	---	---	X	---	---
Trichoptera (caddisflies)	Phryganeidae	---	X	---	X	---	---
Odonata (dragonflies and damselflies)	Coenagrionidae, Lestidae, Calopterygidae, Gomphidae, Libellulidae, Aeshnidae	X	---	---	X	---	---
Megaloptera (alderflies)	Sialidae	X	---	---	X	---	---
Lepidoptera (moths)	Cosmopteridae, Tortricidae, Pyralidae	---	X	---	X	---	---
Coleoptera (beetles)	Dytiscidae, Hydrophilidae (larvae only)	X	---	---	X	---	---
Coleoptera (beetles)	Gyrinidae	X	---	---	---	X	---
Coleoptera (beetles)	Hydrophilidae (adults only), Hydroscaphidae	---	X	X	---	---	---
Coleoptera (beetles)	Noteridae, Scirtidae, Haliplidae	---	X	---	X	---	---
Diptera (horseflies, craneflies, biting midges)	Tabanidae, Tipulidae, Ceratopogonidae	---	X	X	---	---	---
Diptera (soldierflies)	Stratyomyidae	---	X	---	X	---	---
Diptera (phantom midges and shoreflies)	Chaoboridae, Ephydridae	X	---	X	---	---	---
Diptera (Chironomid midges)	Chironomidae (all genera except Parachironomus and Cryptochironomus)	---	X	---	X	---	---
Diptera (Chironomid midges)	Chironomidae (Parachironomus and Cryptochironomus only)	X	---	---	X	---	---
Diptera (mosquitoes)	Culicidae	---	X	---	---	X	---
Orthoptera (grasshoppers)	Tridactylidae, Tettrigidae	---	X	---	---	---	X
Acarina (water mites)	Eylaidae, Hydrachnidae, Axonopsidae	X	---	X	---	---	---

Table 4-2. Complete list of aquatic invertebrate taxa collected at Lisbon Bottom.

Main Group	Family	Genus	Species	Wetland Number[1]												Main-stem[2]	Chute[2]
				2	4	5	7	8	9	10	11	12	16	22	26		
Turbellaria	Planariidae	*Dugesia*				X											
Nematoda																	
Oligochaeta	Tubificidae			X	X	X	X	X			X	X	X	X		X	
Oligochaeta	Naididae			X	X	X	X	X	X	X				X	X	X	
Hirudinea	Glossiphoniidae															X	
Hirudinea	Glossiphoniidae	*Erpobdella*	*punctata*		X						X	X					
Hirudinea	Glossiphoniidae	*Placobdella*	*papillifera*	X		X					X	X			X		
Hirudinea	Glossiphoniidae	*Marvinmeveria*	*lucida*									X					
Pelecypoda	Sphaeriidae	*Sphaerium*		X	X	X						X				X	
Gastropoda	Physidae	*Physa*		X	X	X	X	X	X	X	X	X	X	X	X		
Gastropoda	Hydrobiidae	*Helisoma*	*trivalis*	X					X		X	X		X	X		
Gastropoda	Lymnaidae	*Pseudosuccinea*															
Gastropoda	Lymnaidae	*Lymnaea*	*obrussa*	X	X			X	X		X	X		X			
Gastropoda	Physidae	*Physella*														X	
Gastropoda	Hydrobiidae	*Somatogyrus*														X	
Decapoda	Orconectidae	*Orconectes*	*luteus*													X	
Decapoda	Orconectidae	*Orconectes*	*virilis*													X	
Decapoda	Orconectidae	*Orconectes*	sp.												X	X	
Decapoda	Orconectidae	*Orconectes*	*immunis*														
Decapoda	Orconectidae	*Palaemonetes*	*kadiakensis*	X	X	X	X	X	X	X		X	X	X	X		
Collembolla	Entomobryidae	*Corynothrix*		X				X									
Collembolla	Entomobryidae															X	
Hemiptera	Corixidae	*Sigara*	sp.													X	
Hemiptera	Corixidae	*Sigara*	*grossolineata*			X	X	X	X		X	X		X			
Hemiptera	Corixidae	*Sigara*	*hubbelli*						X			X	X	X			
Hemiptera	Corixidae	*Sigara*	*alternata*	X		X	X	X	X	X	X		X	X	X		
Hemiptera	Corixidae	*Corisella*					X								X		
Hemiptera	Corixidae	*Hesperocorixa*	*lucida*									X					
Hemiptera	Corixidae	*Hesperocorixa*	*obliqua*	X								X		X	X		
Hemiptera	Corixidae	*Palmacorixa*	*buenoi*		X		X	X	X			X	X		X		
Hemiptera	Corixidae	*Trichocorixa*	*calva*	X	X	X	X	X	X	X	X	X	X	X	X		
Hemiptera	Corixidae	*Trichocorixa*	*kanza*	X	X	X	X	X	X	X	X	X	X	X	X		
Hemiptera	Corixidae	*Ramphocorixa*	*acuminata*	X			X	X	X			X	X		X		
Hemiptera	Notonectidae	*Notonecta*	*irrorata*								X						
Hemiptera	Notonectidae	*Notonecta*	*undulata*			X					X						
Hemiptera	Notonectidae	*Notonecta*	*raleighii*														
Hemiptera	Notonectidae	*Notonecta*	*indica*				X			X	X						
Hemiptera	Notonectidae	*Buenoa*	*confusa*				X										
Hemiptera	Naucoridae	*Pelocoris*	*femoratus*									X	X				
Hemiptera	Saldidae	*Micracanthia*	*humulis*							X							

[1] Numbered wetlands sampled in this study
[2] Data from Poulton and others,in press; and Bataille and others, 1999

Table 4-2. Complete list of aquatic invertebrate taxa collected at Lisbon Bottom—Continued.

				Wetland Number[1]													
Main Group	Family	Genus	Species	2	4	5	7	8	9	10	11	12	16	22	26	Main-stem[2]	Chute[2]
Hemiptera	Gelastocoridae	*Gelastocoris*	*oculatus*			X	X					X					
Hemiptera	Nepidae	*Ranatra*	*fusca*				X	X			X						
Hemiptera	Nepidae	*Ranatra*	*australis*		X	X	X					X	X		X		
Hemiptera	Belostomatidae	*Belostoma*	*fluminea*	X			X	X	X	X	X	X	X	X	X		
Hemiptera	Mesoveliidae	*Mesovelia*	*cryptophila*			X											
Hemiptera	Mesoveliidae	*Mesovelia*	*mulsanti*		X	X	X							X			
Hemiptera	Gerridae	*Gerris*	*marginatus*	X	X	X	X		X	X	X	X	X	X	X		
Hemiptera	Gerridae	*Trepobates*	*knighti*		X	X	X	X				X		X	X		
Hemiptera	Gerridae	*Rheumatobates*	*rileyi*	X	X	X			X		X	X		X			
Hemiptera	Hydrometridae	*Hydrometra*	*martini*					X				X		X			
Hemiptera	Pleidae	*Neoplea*	*striola*		X	X	X					X			X		
Amphipoda	Gammaridae	*Gammarus*	*lacustris*		X			X	X	X	X	X		X			
Amphipoda	Taltridae	*Hyallela*	*azteca*		X	X	X	X	X		X		X	X		X	
Ephemeroptera	Isonychiidae	*Isonychia*	*sicca*													X	
Ephemeroptera	Oligoneuriidae	*Homoeoneuria*	sp.														X
Ephemeroptera	Tricorythidae	*Tricorythodes*	sp.			X							X			X	
Ephemeroptera	Leptophlebiidae	*Leptophlebia*	sp.				X	X						X		X	
Ephemeroptera	Ephemeridae	*Hexagenia*	*limbata*		X	X	X	X	X		X		X	X	X	X	
Ephemeroptera	Ephemeridae	*Hexagenia*	*bilineata*													X	
Ephemeroptera	Ephemeridae	*Hexagenia*	*munda*					X						X			
Ephemeroptera	Ephemeridae	*Hexagenia*	*atrocaudata*														
Ephemeroptera	Ephemeridae	*Hexagenia*	*rigida*			X	X	X									
Ephemeroptera	Ephemeridae	*Pentagenia*	*vittigera*													X	
Ephemeroptera	Caeniidae	*Amercaenis*	*ridens*													X	
Ephemeroptera	Caeniidae	*Caenis*	*punctata*	X	X	X		X	X		X	X	X	X	X	X	
Ephemeroptera	Caeniidae	*Caenis*	*lattipennis*		X			X			X	X		X		X	
Ephemeroptera	Caeniidae	*Caenis*	*hilaris*													X	
Ephemeroptera	Baetidae	*Baetis*	*intercalaris*													X	
Ephemeroptera	Baetidae	*Baetis*	sp.													X	
Ephemeroptera	Baetidae	*Labiobaetis*	*longipalis*													X	
Ephemeroptera	Baetidae	*Callibaetis*	*fluctuans*	X		X			X	X	X	X	X	X	X		
Ephemeroptera	Baetidae	*Paracleodes*	*minutus*								X		X		X		
Ephemeroptera	Ephemerellidae																
Ephemeroptera	Heptageniidae	*Raptoheptagenia*	*cruenata*													X	
Ephemeroptera	Heptageniidae	*Heptagenia*	*diabasia*			X			X				X				
Ephemeroptera	Heptageniidae	*Heptagenia*	*flavescens*													X	
Ephemeroptera	Heptageniidae	*Stenacron*	*interpunctatum*													X	
Ephemeroptera	Heptageniidae	*Stenonema*	*integrum*		X	X	X	X	X				X	X		X	
Ephemeroptera	Heptageniidae	*Stenonema*	*femoratum*											X		X	
Ephemeroptera	Heptageniidae	*Stenonema*	*pulchellum*													X	

[1] Numbered wetlands samples in this study
[2] Data from Poulton and others, in press; and Bataille and others, 1999

Table 4-2. Complete list of aquatic invertebrate taxas collected at Lisbon Bottom–Continued.

				Wetland Number[1]													
Main Group	Family	Genus	Species	2	4	5	7	8	9	10	11	12	16	22	26	Main-stem[2]	Chute[2]
Ephemeroptera	Heptageniidae	*Stenonema*	*terminatum*													X	
Ephemeroptera	Heptageniidae	*Leucrocuta*	sp.													X	
Ephemeroptera	Heptageniidae	*Nixe*	sp.													X	
Ephemeroptera	Pseudironidae	*Pseudiron*	*centralis*														X
Ephemeroptera	Baetiscidae	*Baetisca*	*obesa*														X
Ephemeroptera	Potamanthidae	*Anthopotamus*	*myops*													X	
Plecoptera	Capniidae	*Allocapnia*	*granulata*													X	
Plecoptera	Pteronarcyidae	*Pteronarcys*	sp.													X	
Plecoptera	Taeniopterygidae	*Taeniopteryx*	*burksi*													X	
Plecoptera	Taeniopterygidae	*Taeniopteryx*	*parvula*													X	
Plecoptera	Taeniopterygidae	*Strophopteryx*	*fasciata*													X	
Plecoptera	Perlodidae	*Hydroperla*	*fugitans*													X	
Plecoptera	Perlodidae	*Isoperla*	*bilineata*													X	
Plecoptera	Perlidae	*Neoperla*	sp.													X	
Plecoptera	Perlidae	*Perlesta*	*cinctipes*								X			X			
Plecoptera	Perlidae	*Perlesta*	sp.													X	
Plecoptera	Perlidae	*Paragnetina*	*kansensis*													X	
Plecoptera	Perlidae	*Attaneuria*	*ruralis*													X	
Plecoptera	Perlidae	*Acroneuria*	*abnormis*													X	
Plecoptera	Perlidae	*Acroneuria*	*evoluta*													X	
Odonata	Coenagrionidae	*Argia*	*aplicalis*		X	X							X				
Odonata	Coenagrionidae	*Argia*	sp.													X	
Odonata	Coenagrionidae	*Enallagma*	sp.													X	
Odonata	Coenagrionidae	*Enallagma*	*signatum*		X	X	X	X					X	X	X		
Odonata	Coenagrionidae	*Enallagma*	*aspersum*	X				X	X	X		X	X	X			
Odonata	Coenagrionidae	*Enallagma*	*civile*			X			X					X	X		
Odonata	Coenagrionidae	*Ischnura*	*hastata*		X	X		X			X	X					
Odonata	Coenagrionidae	*Ischnura*	*verticalis*		X	X		X	X	X	X	X	X	X			
Odonata	Coenagrionidae	*Ischnura*	*posita*	X	X			X			X	X	X	X			
Odonata	Lestidae	*Lestes*	*rectangularis*	X			X		X	X	X	X		X			
Odonata	Coenagrionidae															X	
Odonata	Calopterygidae	*Hetaerina*	sp.													X	
Odonata	Calopterygidae	*Calopteryx*	*maculatum*								X			X			
Odonata	Gomphidae	*Stylurus*	*plagiatus*			X		X					X			X	X
Odonata	Gomphidae	*Gomphurus*	*externus*													X	X
Odonata	Gomphidae	*Gomphurus*	*ozarkanus*													X	
Odonata	Gomphidae	*Gomphus*	sp.													X	
Odonata	Gomphidae	*Dromogomphus*	sp.													X	
Odonata	Gomphidae															X	
Odonata	Corduliidae	*Neurocordulia*	sp.													X	

[1] Numbered wetlands sampled in this study.
[2] Data from Poulton and others, in press; and Bataille and others, 1999.

Table 4-2. Complete list of aquatic invertebrate taxa collected at Lisbon Bottom–Continued.

Main Group	Family	Genus	Species	Wetland Number[1] 2	4	5	7	8	9	10	11	12	16	22	26	Main-stem[2]	Chute[2]
Odonata	Corduliidae	*Epicordulia*	*princeps*													X	X
Odonata	Corduliidae	*Somatochlora*	*tenebrosa*								X						
Odonata	Libellulidae	*Pachydiplax*	*longipennis*			X						X					
Odonata	Libellulidae	*Libellula*	*luctuosa*									X					
Odonata	Libellulidae	*Libellula*	*pulchella*								X	X					
Odonata	Libellulidae	*Perithemis*	*tenera*			X											
Odonata	Libellulidae	*Plathemis*	*lydia*		X		X	X				X	X				
Odonata	Libellulidae	*Sympetrum*	*vicinctum*									X					
Odonata	Libellulidae	*Erythemis*	*simplicicollis*									X					
Odonata	Libellulidae	*Tramea*	*lacerata*									X					
Odonata	Aeschnidae	*Anax*	*junius*			X					X	X	X				
Odonata	Aeschnidae	*Nasiaeschna*	*pentacantha*		X	X			X								
Odonata	Aeschnidae	*Aeschna*	*umbrosa*					X									
Megaloptera	Sialidae	*Sialis*	sp.				X									X	
Megaloptera	Corydalidae	*Corydalus*	*cornutus*													X	
Lepidoptera																X	
Lepidoptera	Cosmopterygidae	*Pyroderces*	sp.										X				
Lepidoptera	Tortricidae	*Archipes*	sp.							X							
Lepidoptera	Pyralidae	*Crambus*	sp.			X											
Trichoptera	Hydropsychidae	*Cheumatopsyche*	sp.													X	
Trichoptera	Hydropsychidae	*Hydropsyche*	*orris*													X	
Trichoptera	Hydropsychidae	*Hydropsyche*	*simulans*													X	
Trichoptera	Hydropsychidae	*Hydropsyche*	*scalaris*													X	
Trichoptera	Hydropsychidae	*Potamyia*	*flava*													X	
Trichoptera	Leptoceridae	*Nectopsyche*	sp.													X	
Trichoptera	Leptoceridae	*Oecetis*	sp.													X	
Trichoptera	Leptoceridae															X	
Trichoptera	Polycentropodidae	*Neureclipsis*	sp.													X	
Trichoptera	Polycentropodidae	*Paranyctiophylax*	sp.													X	
Trichoptera	Polycentropodidae															X	
Trichoptera	Hydroptilidae	*Hydroptila*	sp.													X	
Trichoptera	Philopotamidae															X	
Trichoptera	Phryganeidae	*Ptilostomis*	sp.				X	X									
Coleoptera	Elmidae	*Macronychus*	sp.													X	
Coleoptera	Elmidae	*Dubiraphia*	sp.													X	
Coleoptera	Elmidae	*Stenelmis*	sp.													X	
Coleoptera	Hydrophilidae	*Tropisternus*	*lateralis*	X					X	X	X	X	X		X		
Coleoptera	Hydrophilidae	*Tropisternus*	*collaris*	X	X	X			X		X	X	X	X	X		
Coleoptera	Hydrophilidae	*Tropisternus*	*blachleyi*		X	X	X	X	X	X		X	X	X			
Coleoptera	Hydrophilidae	*Tropisternus*	*natator*	X	X	X						X		X			

[1] Numbered wetlands sampled in this study.
[2] Data from Poulton and others, in press; and Bataille and others, 1999.

Table 4-2. Complete list of aquatic invertebrate taxa collected at Lisbon Bottom–Continued.

				Wetland Number[1]													
Main Group	Family	Genus	Species	2	4	5	7	8	9	10	11	12	16	22	26	Main-stem[2]	Chute[2]
Coleoptera	Hydrophilidae	*Tropisternus*	larvae	X	X	X	X	X	X	X	X	X	X	X	X		
Coleoptera	Hydrophilidae	*Berosus*	*pantherinus*	X	X	X	X	X				X	X		X		
Coleoptera	Hydrophilidae	*Berosus*	*striatus*	X	X		X	X	X	X		X		X	X		
Coleoptera	Hydrophilidae	*Berosus*	*infuscatus*	X	X		X					X	X		X		
Coleoptera	Hydrophilidae	*Berosus*	*peregrinus*									X					
Coleoptera	Hydrophilidae	*Berosus*	*pugnax*	X													
Coleoptera	Hydrophilidae	*Berosus*	*ordinatus*		X		X	X							X		
Coleoptera	Hydrophilidae	*Berosus*	larvae	X	X					X	X		X	X	X		
Coleoptera	Hydrophilidae	*Berosus*	sp.													X	
Coleoptera	Hydrophilidae	*Crenitis*	sp.	X						X							
Coleoptera	Hydrophilidae	*Hydrobiomorpha*	sp.			X											
Coleoptera	Hydrophilidae	*Hydrophilus*	larvae	X						X		X		X			
Coleoptera	Gyrinidae	*Dineutus*		X	X	X	X	X	X	X		X	X	X	X		
Coleoptera	Gyrinidae	*Gyrinus*		X				X	X	X			X	X		X	
Coleoptera	Noteridae					X						X		X			
Coleoptera	Scirtidae	*Prionocyphon*	sp.			X						X					
Coleoptera	Scirtidae															X	
Coleoptera	Haliplidae	*Peltodytes*	larvae														
Coleoptera	Haliplidae	*Peltodytes*	*lengi*			X	X		X			X					
Coleoptera	Haliplidae	*Peltodytes*	*edentulus*		X	X		X	X		X	X	X	X	X		
Coleoptera	Haliplidae	*Peltodytes*	*totrulosis*	X	X				X		X	X					
Coleoptera	Haliplidae	*Peltodytes*	*duodecimpunctatus*									X					
Coleoptera	Haliplidae	*Peltodytes*	*sexmaculatus*	X	X	X	X	X				X	X	X			
Coleoptera	Haliplidae	*Halplus*	sp.	X	X		X							X			
Coleoptera	Hydroscaphidae	*Hydroscapha*	sp.								X			X	X		
Coleoptera	Dytiscidae	*Acilius*	sp.											X			
Coleoptera	Dytiscidae	*Laccophilus*	sp.	X	X	X	X	X	X	X	X	X	X	X	X		
Coleoptera	Dytiscidae	*Coptotomus*	sp.	X	X		X		X	X		X	X	X	X		
Coleoptera	Dytiscidae	*Agabetes*	sp.				X	X	X			X		X			
Coleoptera	Dytiscidae	*Anodochelius*	sp.	X							X	X	X				
Coleoptera	Dytiscidae	*Hygrotus*	sp.				X						X	X	X		
Coleoptera	Dytiscidae	*Hydroporus*	sp.	X	X	X	X	X	X	X	X	X	X	X	X		
Coleoptera	Dytiscidae	*Hydrovatus*	sp.	X								X					
Coleoptera	Dytiscidae	*Cybister*	sp.				X					X		X			
Coleoptera	Dytiscidae	*Nebrioporus*	sp.		X								X				
Coleoptera	Dytiscidae	*Hydaticus*	sp.												X		
Coleoptera	Dytiscidae	*Agabus*	sp.	X					X			X		X			
Coleoptera	Dytiscidae	*Oreodytes*	sp.	X		X			X	X				X			
Coleoptera	Dytiscidae	*Copelatus*	sp.			X					X						
Diptera	Tipulidae															X	

[1] Numbered wetlands sampled in this study.
[2] Data from Poulton and others, in press; and Bataille and others, 1999.

Table 4-2. Complete list of aquatic invertebrate taxa collected at Lisbon Bottom—Continued.

				Wetland Number[1]													
Main Group	**Family**	**Genus**	**Species**	**2**	**4**	**5**	**7**	**8**	**9**	**10**	**11**	**12**	**16**	**22**	**26**	**Main-stem[2]**	**Chute[2]**
Diptera	Tipulidae	*Ormosia*	sp.								X						
Diptera	Simulidae	*Simulium*	sp.													X	
Diptera	Simulidae	*Ectemnia*	sp.													X	
Diptera	Tabanidae	*Tabanus*	sp.					X			X						
Diptera	Ceratopogonidae															X	
Diptera	Ceratopogonidae	*Bezzia*	sp.		X	X	X	X	X		X	X	X			X	
Diptera	Ceratopogonidae	*Dasyhelea*	sp.	X													
Diptera	Chironomidae	*Axaris*														X	
Diptera	Chironomidae	*Dicrotendipes*		X	X	X								X		X	
Diptera	Chironomidae	*Chironomus*		X	X	X	X	X	X	X	X		X	X	X	X	
Diptera	Chironomidae	*Tribelos*		X							X		X	X		X	
Diptera	Chironomidae	*Cryptochironomus*		X	X		X	X	X		X		X	X		X	
Diptera	Chironomidae	*Polypedilum*			X	X	X	X	X		X	X	X	X	X	X	
Diptera	Chironomidae	*Endochironomus*		X	X	X	X			X		X		X	X		
Diptera	Chironomidae	*Parachironomus*					X						X			X	
Diptera	Chironomidae	*Glyptotendipes*		X	X	X	X	X	X			X	X	X		X	
Diptera	Chironomidae	*Stenochironomus*														X	
Diptera	Chironomidae	*Paratendipes*														X	
Diptera	Chironomidae	*Paracladopelma*											X		X	X	
Diptera	Chironomidae	*Cladotanytarsus*															
Diptera	Chironomidae	*Paratanytarsus*									X					X	
Diptera	Chironomidae	*Tanytarsus*					X				X		X			X	
Diptera	Chironomidae	*Rheotanytarsus*														X	
Diptera	Chironomidae	*Robackia*														X	
Diptera	Chironomidae	*Chernovskiia*														X	
Diptera	Chironomidae	*Epoicocladius*														X	
Diptera	Chironomidae	*Eukiefferiella*									X	X				X	
Diptera	Chironomidae	*Hydrobaenus*									X			X		X	
Diptera	Chironomidae	*Orthocladius*				X					X			X		X	
Diptera	Chironomidae	*Tvetenia*														X	
Diptera	Chironomidae	*Cricotopus*		X	X	X	X			X		X	X	X		X	
Diptera	Chironomidae	*Rheocricotopus*														X	
Diptera	Chironomidae	*Lopescladius*										X					
Diptera	Chironomidae	*Procladius*		X	X		X	X	X	X	X		X	X	X	X	
Diptera	Chironomidae	*Ablabesmyia*		X	X	X	X				X	X	X			X	
Diptera	Chironomidae	*Alotanypus*														X	
Diptera	Chironomidae	*Pentaneuriella*														X	
Diptera	Chironomidae	*Tanypus*		X		X		X			X		X	X		X	
Diptera	Chironomidae	*Coelotanypus*				X											
Diptera	Chironomidae	*Thienemannimyia*			X									X			

[1] Numbered wetlands sampled in this study.
[2] Data from Poulton and others, in press; and Bataille and others, 1999.

Table 4-2. Complete list of aquatic invertebrate taxa collected at Lisbon Bottom–Continued.

				Wetland Number[1]													
Main Group	**Family**	**Genus**	**Species**	**2**	**4**	**5**	**7**	**8**	**9**	**10**	**11**	**12**	**16**	**22**	**26**	**Main-stem[2]**	**Chute[2]**
Diptera	Chironomidae	*Zavrelimyia*															
Diptera	Chaoboridae	*Chaoborus*		X			X	X	X	X			X	X		X	
Diptera	Empididae	*Hemerodromia*														X	
Diptera	Psychodidae	*Psychoda*														X	
Diptera	Stratyomyidae	*Stratyomys*				X					X						
Diptera	Ephydridae	*Ephydra*						X				X		X			
Diptera	Sciomyzidae								X		X	X					
Diptera	Culicidae	*Haemagogus*		X							X	X					
Diptera	Culicidae	*Anopheles*					X	X	X					X	X		
Diptera	Culicidae	*Culex*										X					
Diptera	Culicidae	*Culiseta*									X						
Hydracarina	Mamsersalidae	*Mamersellides*								X		X					
Hydracarina	Eylaidae	*Eylais*							X			X			X		
Hydracarina	Hydrachnidae	*Hydrachna*												X			
Hydracarina	Axonopsidae	*Albia*											X				
Hydracarina																X	
Nematomorpha	Gordiidae	*Gordius*					X										
Eubranchiopoda	Conchostraca	*Lynceus*						X	X								
Orthoptera	Tridactylidae	*Neotridactylus*	*aplicialis*	X			X	X	X								
Orthoptera	Tettrigidae	*Tettigidea*	*lateralis*	X		X	X	X	X		X	X	X	X	X		

[1] Numbered wetlands sampled in this study.
[2] Data from Poulton and others, in press; and Bataille and others, 1999.

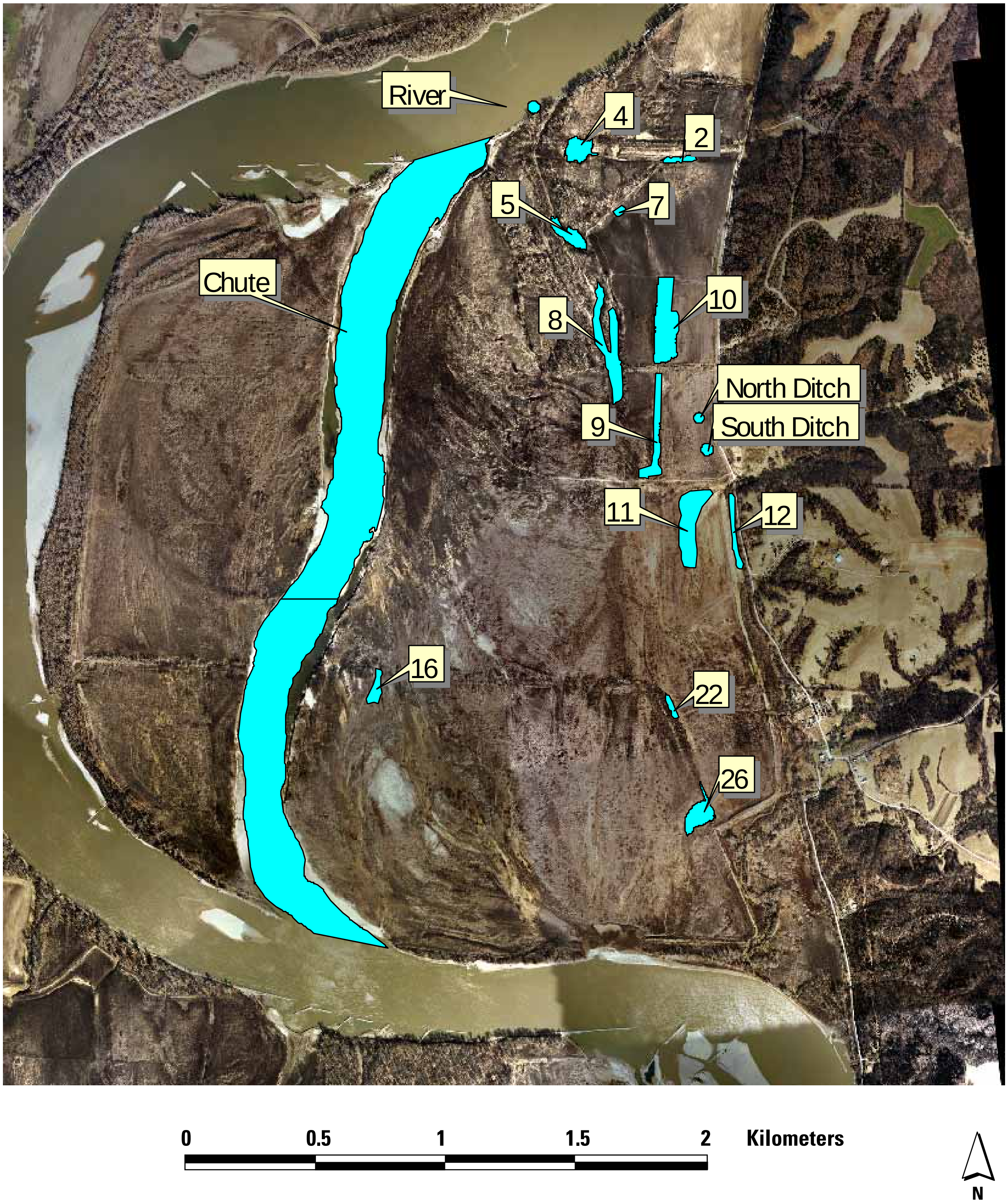

Figure 4-1. Map of Lisbon Bottom wetlands that were sampled for aquatic invertebrates. *Background photo courtesy of U.S. Army Corps of Engineers, Kansas City, MO, March 2000.*

A

B

Figure 4-2. A. Quantitative invertebrate sampling using the stovepipe sampler.
B. Qualitative invertebrate sampling using the sweep net.

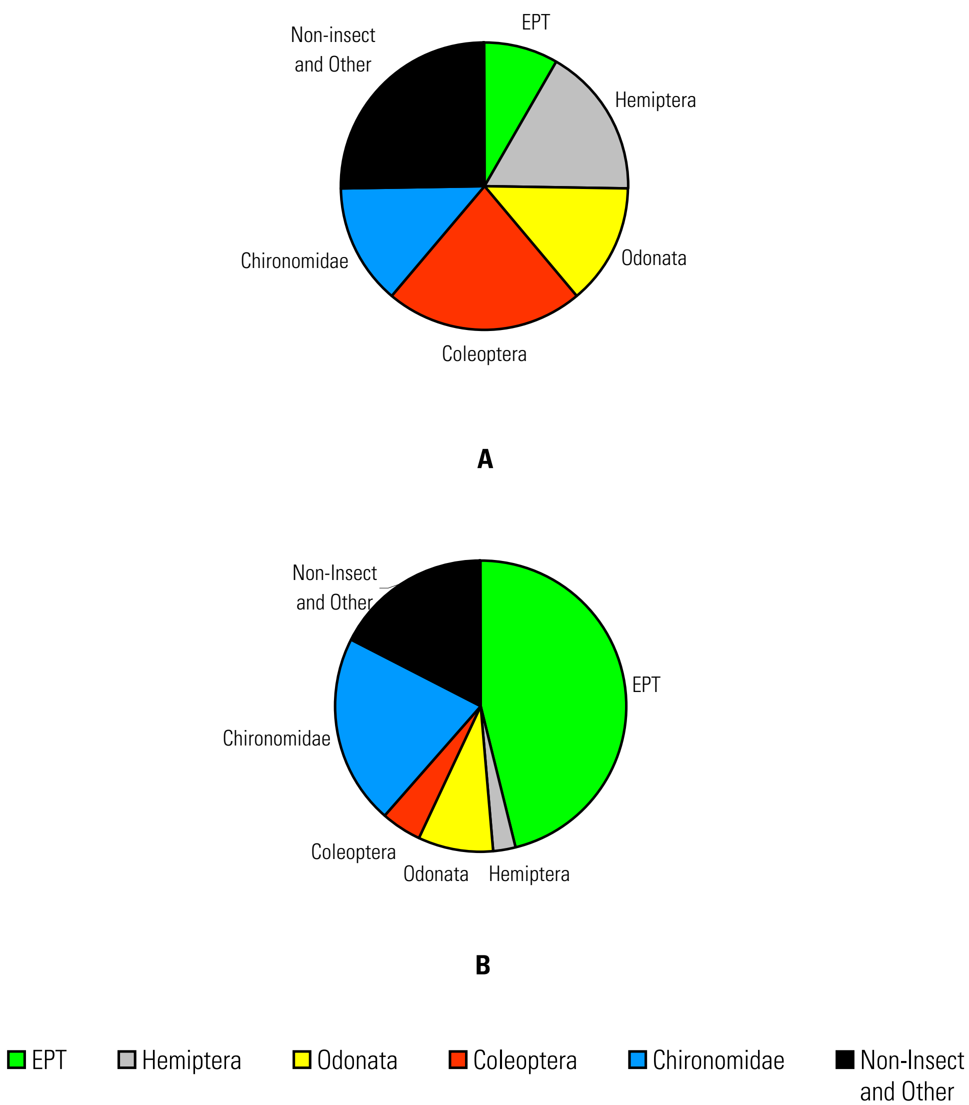

Figure 4-3. A. Number of species among different aquatic invertebrate groups known to exist in the wetlands at Lisbon Bottom. **B.** Number of species among aquatic invertebrate groups known to exist in the mainstem of the Lower Missouri River (EPT= Ephemeroptera, Plecoptera and Trichoptera).

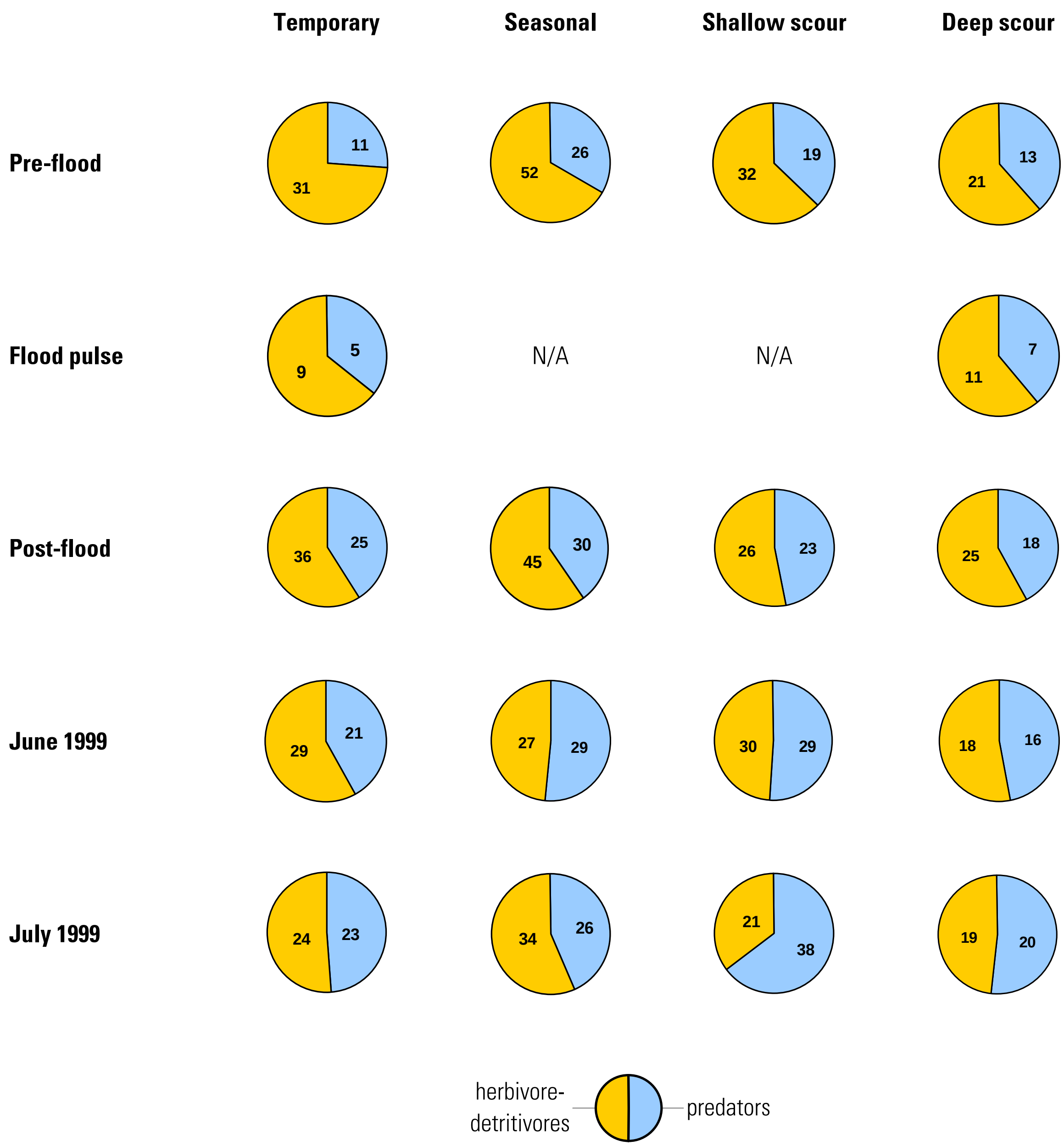

Figure 4-4. Taxa richness of invertebrate predators (in blue on right) and herbivore-detritivores (in yellow on left) over time for the different wetland types at Lisbon Bottom. Temporary wetlands (2, 9, 10) and deep scours (4, 26) were sampled during the flood-pulse period of 4/16 thru 5/13, whereas seasonal and semi-permanent wetlands (8, 11, 12, 22) and shallow scours or remnant wetlands (5, 7, 16) were not accessible for qualitative sampling during that time due to high water.

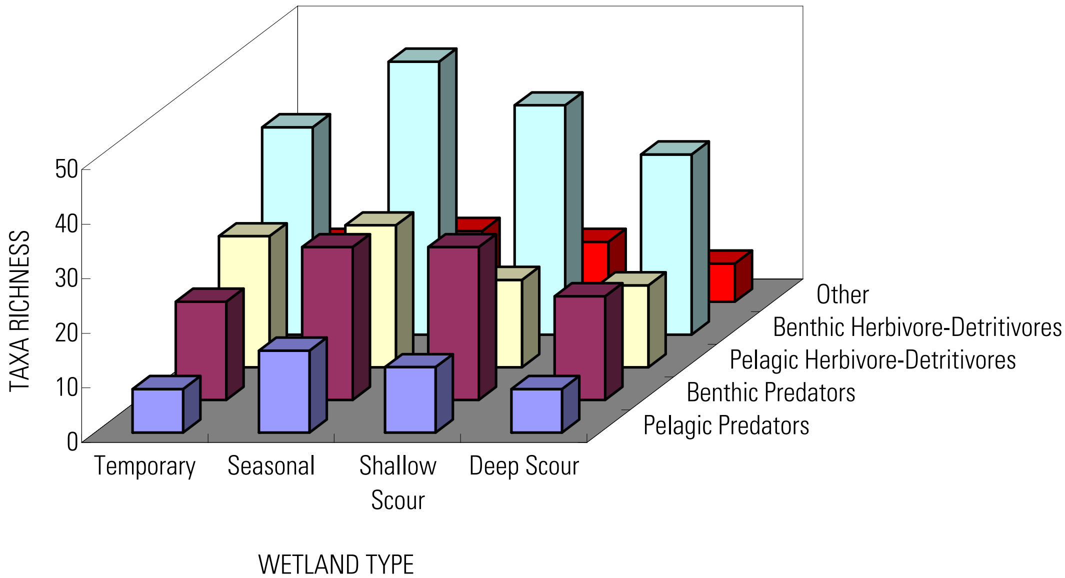

Figure 4-5. Distribution of total invertebrate taxa richness among functional groups for different wetland types at Lisbon Bottom, 1999.

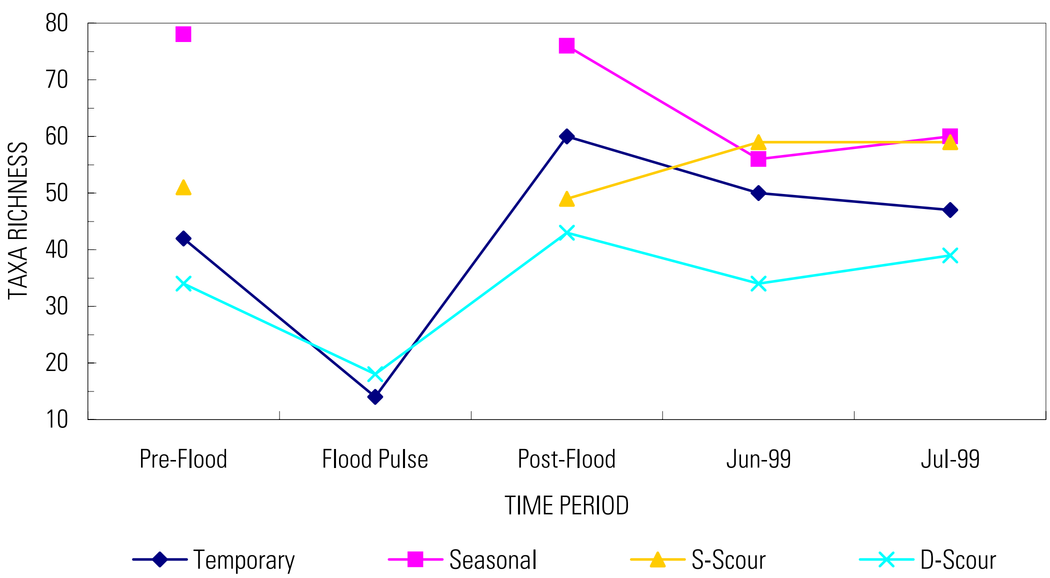

Figure 4-6. Total taxa richness of invertebrates collected over time from different wetland types at Lisbon Bottom in 1999. Temporary wetlands (2, 9, 10) and deep scours (4, 26) were sampled during the flood-pulse period of 4/16 through 5/13, whereas seasonal and semi-permanent wetlands (8, 11, 12, 22) and shallow scours or remnant wetlands (5, 7, 16) were not accessible for qualitative sampling during that time due to high water.

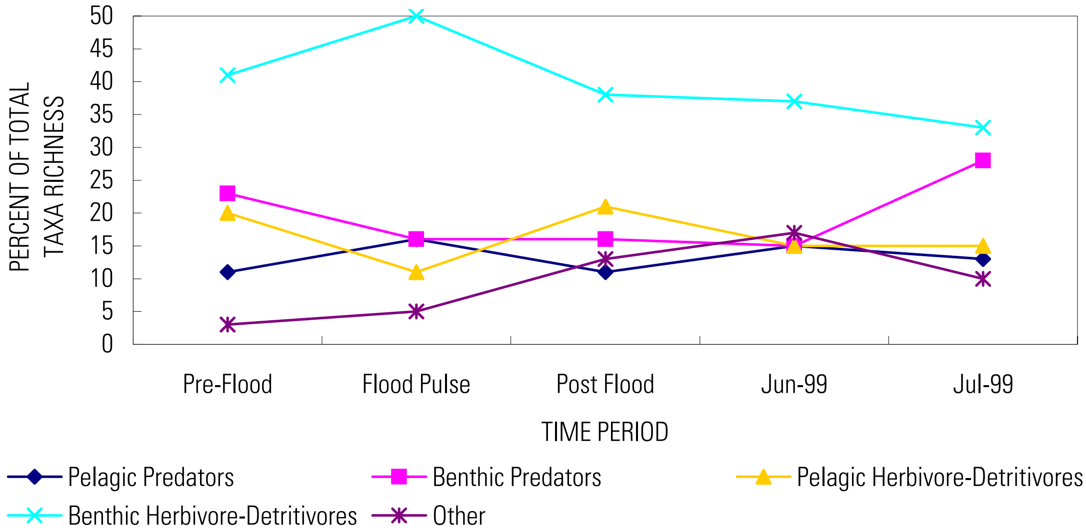

Figure 4-7. Relative percent (%) of the total taxa richness in deep scours (4, 26) of functional feeding groups of invertebrates at Lisbon Bottom. The invertebrate category "other" includes pleuston (surface-dwelling) and semi-aquatic species.

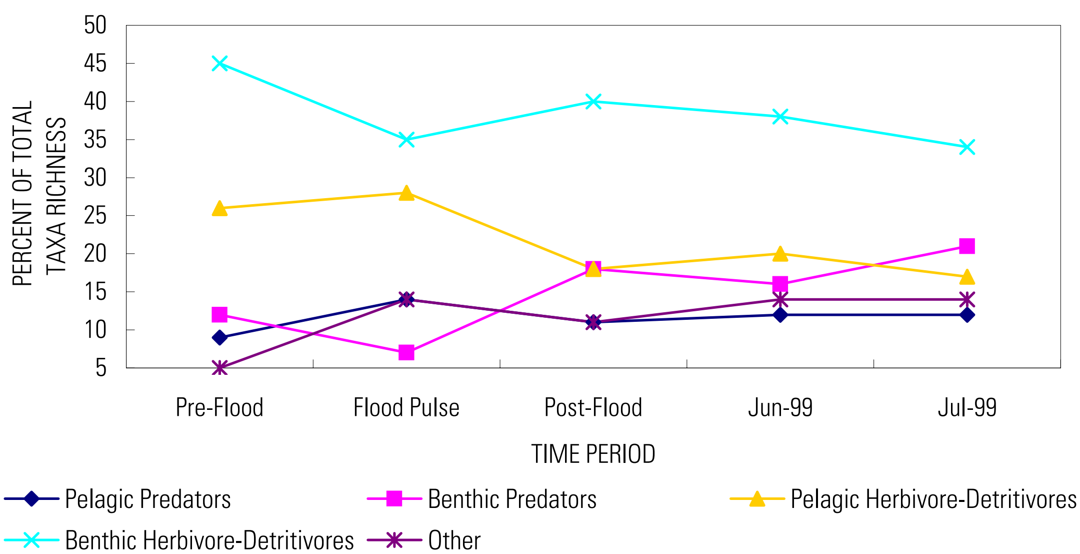

Figure 4-8. Relative percent (%) of the total taxa richness in temporary wetlands (2, 9, 10) of functional feeding groups of invertebrates at Lisbon Bottom. The invertebrate category "other" includes pleuston (surface-dwelling) and semi-aquatic species.

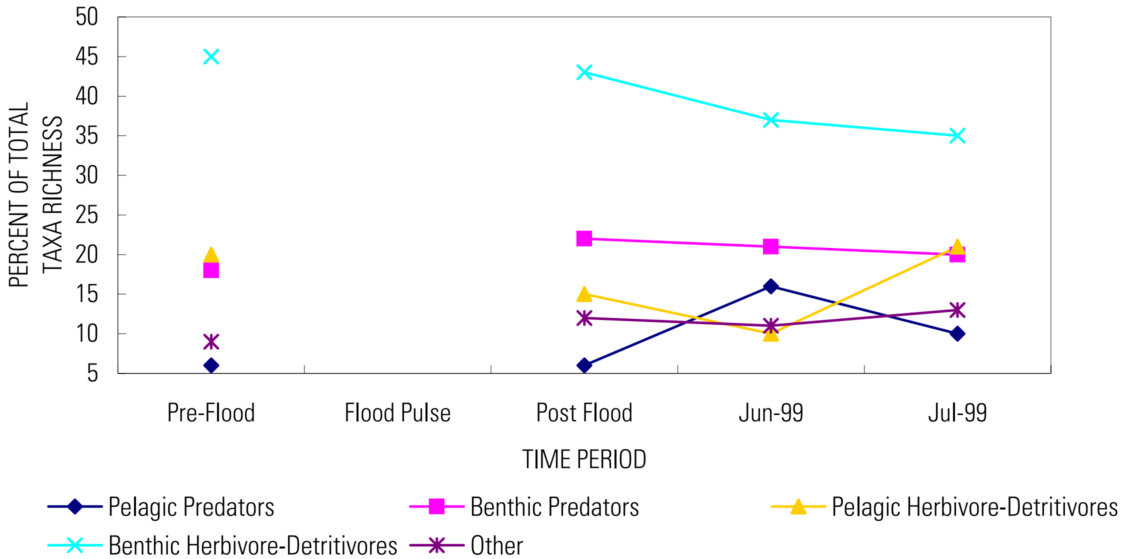

Figure 4-9. Relative percent (%) of the total taxa richness in seasonal and semi-permanent wetlands (8, 11, 12, 22) of functional feeding groups of invertebrates at Lisbon Bottom. The invertebrate category "other" includes pleuston (surface-dwelling) and semi-aquatic species.

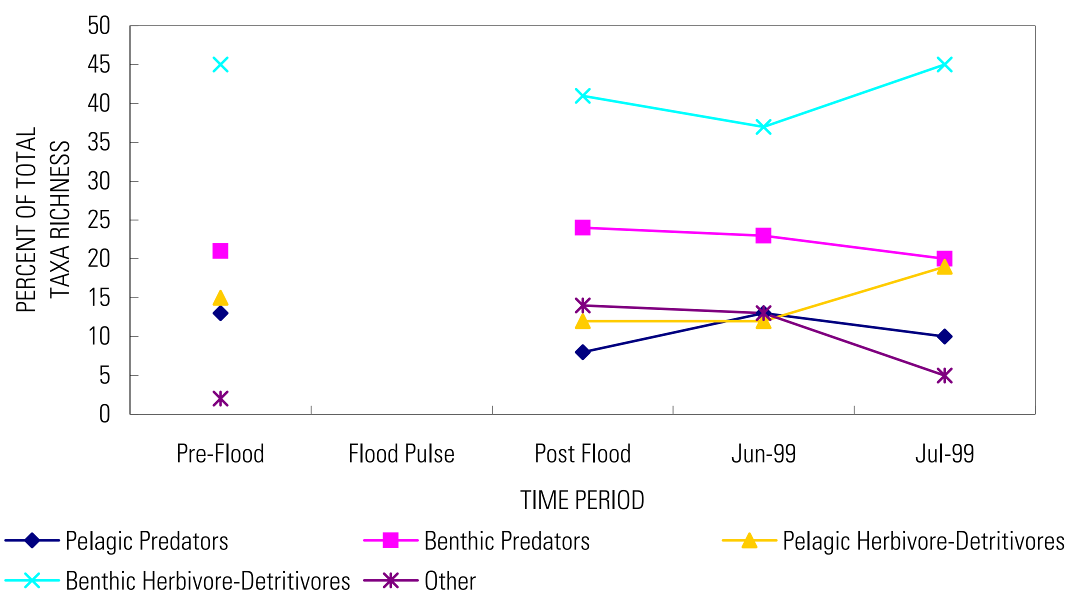

Figure 4-10. Relative percent (%) of the total taxa richness in shallow scours and remnant wetlands (5, 7, 16) for functional feeding groups of invertebrates at Lisbon Bottom. The invertebrate category "other" includes pleuston (surface-dwelling) and semi-aquatic species.

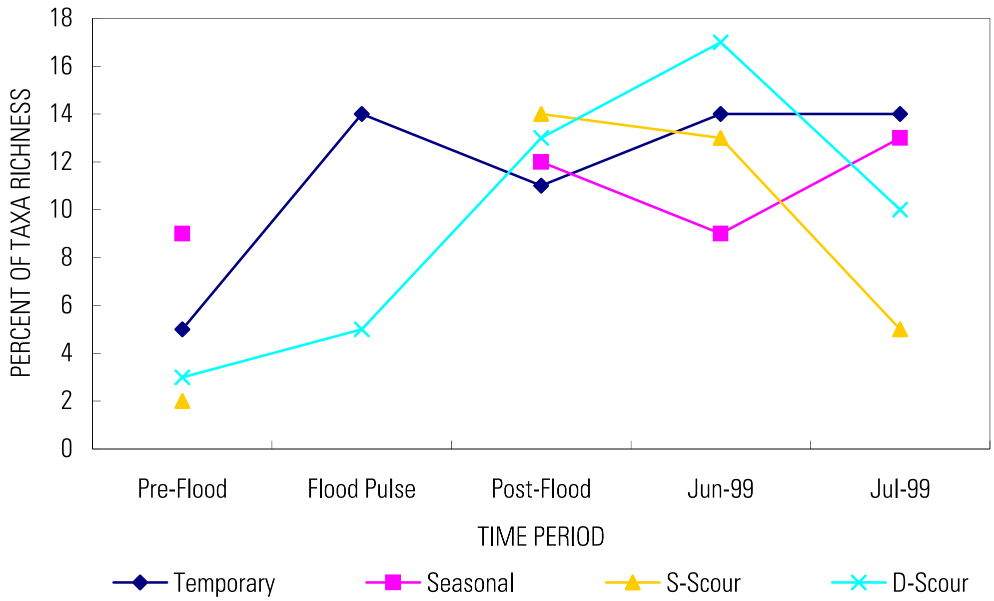

Figure 4-11. Relative percent of semi-aquatic and surface-dwelling (pleuston) invertebrates based on taxa richness observed in different wetland types at Lisbon Bottom in 1999. Temporary wetlands (2, 9, 10) and deep scours (4, 26) were sampled during the flood-pulse period of 4/16 through 5/13, whereas seasonal and semi-permanent wetlands (8, 11, 12, 22) and shallow scours or remnant wetlands (5, 7, 16) were not accessible for qualitative sampling during that time due to high water.

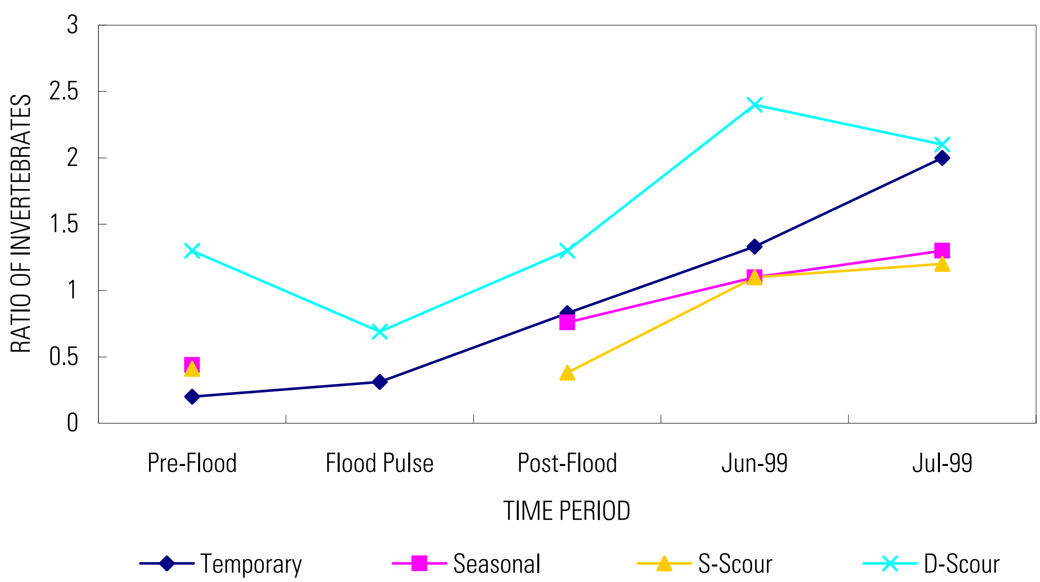

Figure 4-12. Ratio of predator / herbivore-detritivore abundances of invertebrates collected from different wetland types at Lisbon Bottom in 1999. Temporary wetlands (2, 9, 10) and deep scours (4, 26) were sampled during the flood-pulse period of 4/16 through 5/13, whereas seasonal and semi-permanent wetlands (8, 11, 12, 22) and shallow scours or remnant wetlands (5, 7, 16) were not accessible for qualitative sampling during that time due to high water.

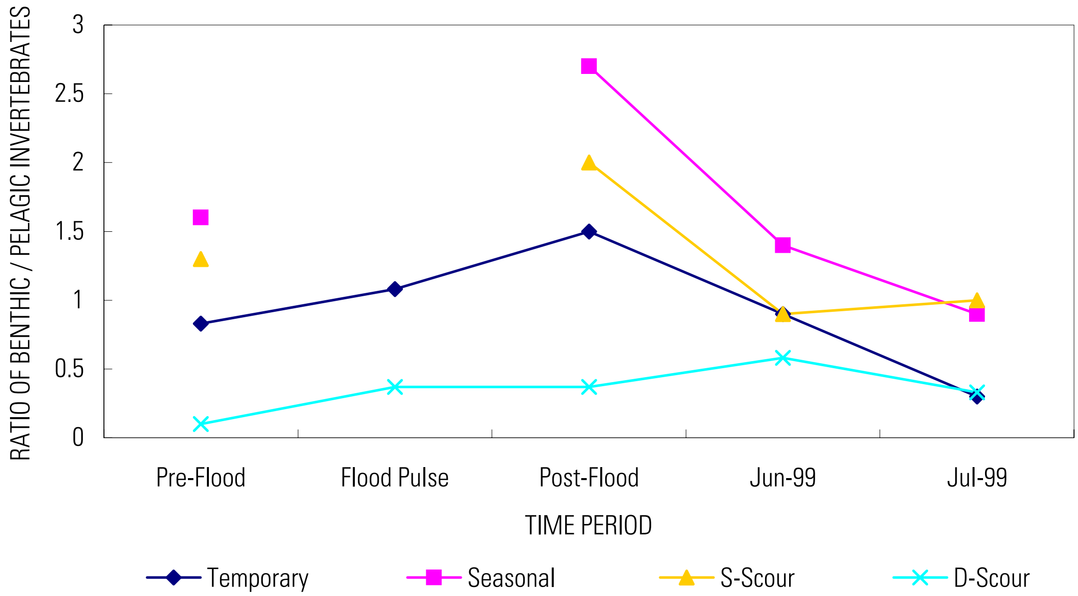

Figure 4-13. Ratio of benthic / pelagic abundances of invertebrates collected from different wetland types at Lisbon Bottom in 1999. Temporary wetlands (2, 9, 10) and deep scours (4, 26) were sampled during the flood-pulse period of 4/16 through 5/13, whereas seasonal and semi-permanent wetlands (8, 11, 12, 22) and shallow scours or remnant wetlands (5, 7, 16) were not accessible for qualitative sampling during that time due to high water.

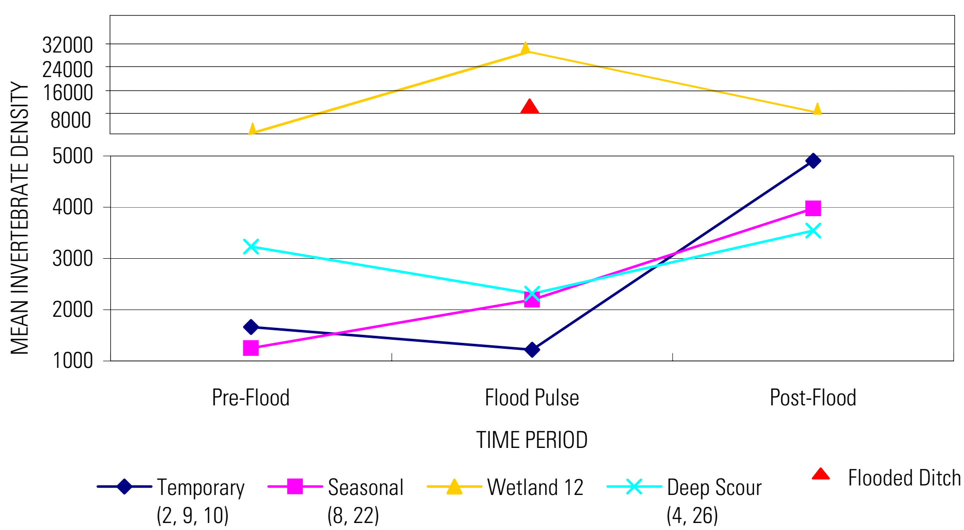

Figure 4-14. Mean invertebrate density (#/m^2) determined from stovepipe samples taken from different wetland basin types at Lisbon Bottom in 1999. During the peak of the flood-pulse period (4/16 – 5/13, with highest stage on 5/3/99) no wetland basins were accessible for quantitative sampling due to high water, and two locations along a flooded ditch were sampled to document high densities of invertebrates observed.

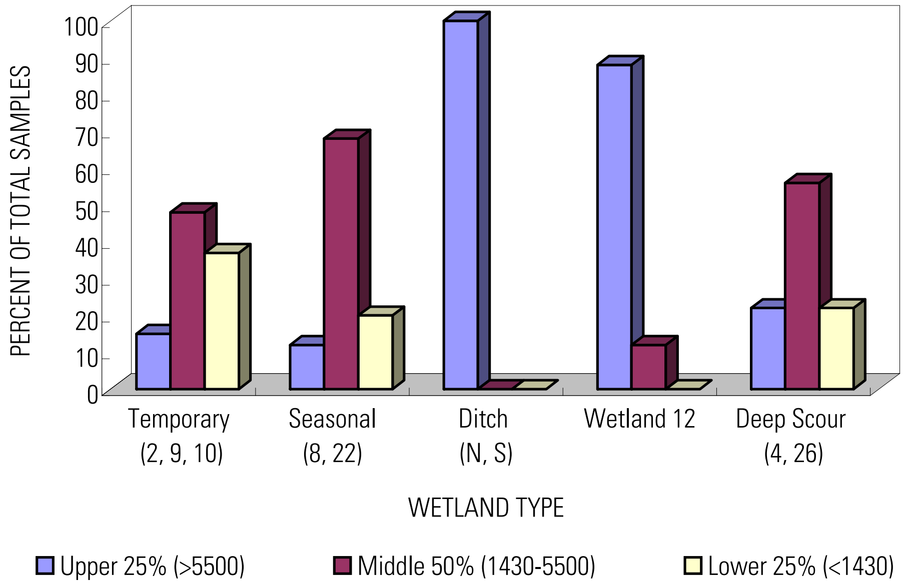

Figure 4-15. Frequency distribution of density classes (percent of total samples taken within a wetland type in #/m^2) for Lisbon aquatic invertebrate samples collected in 1999 during periods when vegetation along wetland margins was inundated.

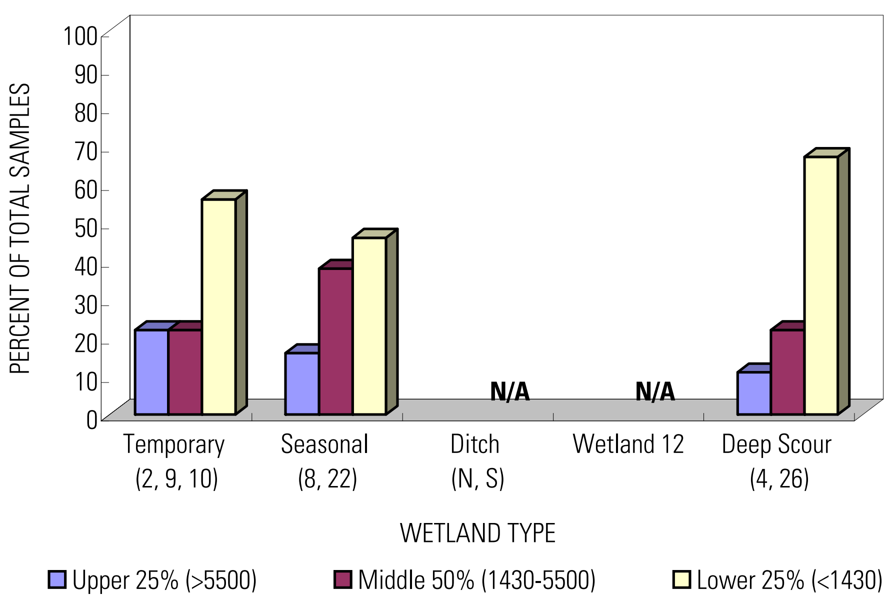

Figure 4-16. Frequency distribution of density classes (percent of total samples taken within a wetland type #/m^2) for Lisbon aquatic invertebrate samples collected in 1999 during periods when vegetation along wetland margins was above the waterline and not inundated.